

‘Phantom’ mannequins will help us understand how cosmic radiation affects female bodies in space

Does space travel affect female and male astronauts differently? Helga, Zohar, and Commander Moonikin Campo are on a mission to find out.



Radiation biologist Thomas Berger inside the Orion capsule with representative mockups of the MARE mannequins. *DLR*

When NASA’s [Artemis 1 mission launches to the moon later this month](#), on board the Orion space capsule will be two special passengers: Helga and Zohar.



The pair are actually mannequin torsos, called phantoms, that are inspired by hospital training tools and are made to mimic human bones, soft tissues, and the internal organs of an adult female. They were borned out of a collaboration with the Israel Space Agency and the German Aerospace Center, and are designed with sensors that can map radiation exposure levels throughout the body. Zohar,

specifically, will wear a radiation protection vest designed to protect the real astronauts slated for future Artemis missions—including the first women to go to the moon.

The last time people set foot on the moon or even traveled beyond low Earth orbit was at the end of the Apollo program in 1972. Back then, the US astronaut corps did not admit women. That changed when the first American female astronaut candidates were selected in 1978, with a young Sally Ride among them. Today, NASA astronauts are much more diverse. But that isn't reflected in the data informing their safety protocols because of decades of male dominance in the field. So, the agency and its collaborators are firing up new experiments to understand how different human bodies respond to the extreme environment of space—and best enable *all* astronauts to do their jobs safely.

"We stand on the shoulders of giants, and we've made a lot of progress. But there's a lot of progress still to be made to understand [the biological nuances between astronauts]," says Jennifer Fogarty, chief scientific officer for the Translational Research Institute for Space Health, which is supported by the NASA Human Research Program and led by the Baylor College of Medicine. The goal, she says, is to build spaceflight tools and healthcare regimens for astronauts "around the human body to give it the ability to do the job you're expected to do, and reduce the possibility of getting into conflict with that body."



Zohar with her vest at the front, while Helga sits at the back. *DLR*

Wear and tear in zero-g

To look for patterns, researchers like Fogarty have been collecting data on how sex differences might influence [astronauts' health in space](#). So far, however, the research on how female bodies respond to the extreme environment of space has been “pretty limited,” she says. To date, [more than 600 people](#) have flown in space; [fewer than 100](#) of them have been women. Tools like Helga and Zohar can help gather data in a way that isn’t reliant on historic trends.

Scientifically, it’s difficult to extrapolate trends in sex differences or sex-specific healthcare that can be trusted based on those numbers because some characteristics could simply be from individual variation. For example, when a female astronaut developed a blood clot while on the International Space Station in 2020, it prompted an investigation into whether the use of hormonal contraceptives for menstrual cycle control increased the risk of clotting during spaceflights. A [review of 38 female astronaut flights published later that](#)

[year](#) concluded that it does not. But given such a small sample size and how rare blood clots associated with hormonal contraceptives are, that question remains open.

In some ways, women have proven particularly “resilient” during spaceflight, Fogarty says. For example, male astronauts’ eyesight seems to be more affected by swelling around the optic nerve in zero gravity than female astronauts’. But according to a 2014 study, [female astronauts have statistically experienced greater orthostatic intolerance](#) (the inability to stand without fainting for a long period of time) upon returning to Earth.



Radiation-sensitive layers from the mannequins that will emulate the female body on the Artemis 1 mission. *DLR*

Radiation poisoning from space

Beyond short-term conditions and changes to bodies, a lot of the focus on human health out in space is focused on exposure to cosmic radiation from stars and

galactic explosions. Most of the data we currently have comes from laboratory research on rodents or observations on atomic bomb survivors, Fogarty says: It shows a pattern of female survivors being more susceptible to developing lung cancer than male ones.

Because women seem to carry more side effects from radiation damage than men, NASA recently updated its standards for acceptable levels of exposure to be uniform, limiting all astronauts to what was previously the allowable dosage for a 35-year-old woman.

Galactic cosmic rays are different from nuclear weapon radiation, however. For one, in nuclear accidents or acts of war exposure is two-dimensional, which means certain organs might be hit with more radiation than others. But, in space, the radiation is “considered omnipresent,” Fogarty says—you’re exposed in every direction. Some calculations suggest that the radiation exposure rate on the moon is about [2.6 times higher](#) than that experienced by astronauts aboard the International Space Station (ISS). Even then, in one week on the ISS, [astronauts can be exposed to the same amount of radiation](#) as humans are over one year on the ground.

With radiation coming from all angles in space, devising a physical barrier like a spacesuit or protective vest can be tricky. It makes understanding how all human organs are affected by radiation exposure important—whether they be sex-specific reproductive organs or not.



Mannequins on their way to the moon on the Artemis 1 mission. *NASA/Lockheed Martin/DLR*

That's where Helga and Zohar come in. The female "phantoms" are part of the [Matroska AstroRad Radiation Experiment](#) (MARE). Internally, they have a grid of 10,000 passive sensors and 34 active radiation detectors that will gather data for researchers on which parts of the body make the most contact with electromagnetic waves during spaceflight. Some organs may be protected by the layers of soft tissue over them, while others may not be—this will help engineers build more targeted systems to protect the most at-risk areas of the body from harmful radiation.

"What we will get besides the difference between a man and a woman when it comes to biological effects, we will get the difference between different body organs. The difference between brain and uterus, for example," said [Ramona Gaza](#), MARE science team lead at NASA's Johnson Space Center, in [a press teleconference](#) this week.

The two torsos won't be the only Artemis 1 experiment designed to study the effects of radiation. There will also be a suite of live organisms, including yeast, fungi, algae, and plant seeds, aboard the mission. In [a NASA project called BioSentinel](#), the Orion capsule will release a CubeSat into orbit around the moon

carrying yeast cells to test on how the organisms survive the deep-space environment.

In total, the Artemis 1 mission will launch 10 CubeSats: The rest will study aspects of the lunar environment that will prove important to characterize for the safety of future human travel to the moon. They include tools to study [space weather](#) and bursts of solar radiation, map stores of water ice on the lunar surface, as well as [a tiny lander](#) from the Japan Aerospace Exploration Agency.

Helga and Zohar also won't be the only "passengers" on Artemis 1. In addition to [a stuffed a sheep](#), they will be joined by a male-bodied mannequin equipped with sensors to measure various aspects of the environment around the moon during the flight, including radiation exposure. While Helga and Zohar won't be wearing spacesuits, [Commander Moonikin Campos](#) will be dressed in a first-generation Orion Crew Survival System, which Artemis astronauts will use when real humans return to the moon.